A Summary of Current Program
and Preliminary Report of Progress
for Fiscal Year 1962

SHEEP AND WOOL RESEARCH

of the State Agricultural Experiment Stations
including cooperation with the
United States Department of Agriculture

Prepared for the

SHEEP AND WOOL RESEARCH AND MARKETING ADVISORY COMMITTEE

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This progress report of research is a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The statements of progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not for publication and should not be referred to in literature citations. Copies are distributed only to members of State experiment stations and USDA staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of State and cooperative research issued during the past year.

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TABLE OF CONTENTS

INTRODUCTION

This is one of two reports prepared for the Sheep and Wool Research and Marketing Advisory Committee. It presents the research program and progress at the State Agricultural Experiment Stations and includes results from cooperative research with the Department. It is parallel to and supplements the report prepared by the Agricultural Research Service which includes the program and progress by the research divisions of the Department and their cooperators.

SUMMARY OF CURRENT PROGRAM OF THE STATE EXPERIMENT STATIONS

Sheep and wool research is conducted by the State Agricultural Experiment Stations mostly within the animal science, veterinary medicine, agricultural biochemistry, entomology, agricultural economics, home economics, and agricultural engineering departments. Support of 74.7 professional man-years are devoted to the current research program. This support is divided among the following areas: increasing efficiency of production 53.3; diseases and parasites 16.8; entomology 0.9; agricultural engineering 0.2; market quality 1.3; economic research 1.3; and human nutrition and consumer use research 1.8.

SUMMARY OF CURRENT PROGRAM OF THE DEPARTMENT

Sheep and wool research is conducted in four of the farm research divisions in the Agricultural Research Service, i.e., in Animal Husbandry, Animal Diseases and Parasites, Entomology, and Agricultural Engineering. Wool and mohair utilization research is conducted by the Western Utilization Research and Development Division at the Albany, California, regional laboratory. Market quality research is conducted by two divisions of AMS, i.e., Market Quality Research and Transportation and Facilities Research Divisions. Economic research specifically dealing with lamb and wool is conducted by two divisions in the Economic Research Service, i.e., Economic and Statistical Analysis and Marketing Economics; by the Farmer Cooperative Service; and by the Statistical Reporting Service. Human Nutrition and Consumer Use research involving lamb and wool is conducted by the Clothing and Housing Research Division, Human Nutrition Research Division and Household Economics Division of the Agricultural Research Service.

The Department is devoting 86.4 professional man-years to the total research program. This support is divided among various areas as follows: utilization 40.6; animal husbandry 16.1; diseases and parasites 14.9; economic research 6.1; entomology 4.9; marketing research 1.8; human nutrition and consumer use research 1.0; and agricultural engineering 0.2.

I. FARM RESEARCH

A. BREEDING

PROBLEM

Continued improvement in the productivity traits of sheep is essential to the competitiveness of this species as a producer of meat and fiber. Variation exists between and within breeds of sheep in levels of performance of all productivity traits including those which contribute directly to quality and quantity of lamb and wool. Much of this variation appears to be of genetic origin. Thus, it appears that considerable improvement can be achieved through breeding and selection. Research is needed to more accurately establish the degree to which various traits are inherited and the progress which can be expected through the application of various breeding procedures. The continued improvement of sheep requires the full exploitation of genetic capabilities for reproduction, growth, fleece yield, disease and parasite resistance, and many other traits.

PROGRAM OF THE STATE EXPERIMENT STATIONS

The program of sheep breeding research at the State Agricultural Experiment Stations has the basic purpose of determining breeding methods for sheep which can be used by the livestock industry in the more efficient production of lamb and wool. This program is conducted through regional projects in three regions where State stations and the USDA work cooperatively and through other station projects which may be conducted cooperatively or independently of other research agencies.

This program currently totals 18.3 professional man-years which are distributed to the following areas: 4.1 man-years to genetics and interrelations of performance traits, 12.3 man-years to selection and systems of breeding, and 1.9 man-years to crossbreeding.

RELATED PROGRAMS OF THE USDA

The USDA scientific effort devoted to research in this area totals 6.3 professional man-years. Of this number 1.5 are devoted to genetics and interrelation of performance traits, 3.1 to selection and systems of breeding, and 1.7 to program leadership.

PROGRESS OF STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

Significant research accomplishments in sheep breeding have been made during the past year by the State Agricultural Experiment Stations working cooperatively with each other and with the USDA through regional research projects and other research projects. Areas of accomplishment include: establishment of experimental flocks for genetic studies, estimation of parameters of economic traits including heritability, genetic interrelations and environmental effects, determination of response to selection and to various systems of breeding, and evaluation of crosses between various breeds of sheep. The accomplishments are described below for each of the regional projects and for other research projects.

Regional Project NC-50

In the North Central region, cooperative sheep breeding research is conducted under regional project NC-50, Improvement of Lamb Meat Production Through Breeding. To insure comparability of initial breeding populations, Illinois, Ohio, and North Dakota have made the third equilateral exchange of lambs between stations. Lambs exchanged in previous years have been and are being bred to produce the first generations for selection. This project is already yielding some results. Shrink of lambs in shipment between the three stations was measured; although no difference between ewes and rams and among the three breeds was found, shrinkage was twice as great in trucking from East to West as in going from West to East. The Illinois station showed a much lower lamb crop than the other two stations, a condition which is a problem of breeders in Southern Illinois. This balanced project should also aid in identifying the cause of this problem.

Wisconsin, with the assistance of the breed association, has assembled from 60 flocks located in 30 States of the United States a breeding flock of 360 Hampshire ewes and 40 rams born in 1962. This flock will form the base for an experiment to compare individual versus individual and family selection for several traits and for a combination of traits.

In comparison of purebreds, 1st crosses, and 3-way cross lambs of Minnesota, lamb crops were 94, 100, and 78 percent respectively. Carcass data from these lambs indicated that on a weight constant basis there were only small differences due to breeding groups.

Work at Kansas and Michigan is concerned largely with carcass traits and their interrelationships among progeny of rams. Kansas has demonstrated significant sire difference for several of these traits.

Regional Project W-61

In the Western region, cooperative sheep breeding research is conducted under regional project W-61, Development of Selection Criteria for the Genetic Improvement of Carcass Merit in Sheep. Eleven western States and the USDA have contributing projects to this regional project which is highly oriented toward improvement of lamb carcasses. While most aspects of this work are discussed elsewhere, the regional project does provide considerable information on growth and other productivity traits pertinent to this section. For instance, the cooperative project of the USDA station at Fort Wingate, New Mexico, and the New Mexico Agricultural Experiment Station has shown that ram lambs are heavier at weaning, require less feed per pound gain, make more rapid gains and are heavier and younger at slaughter than wether lambs. Similarly ram lambs exceed ewe lambs in all of these traits. In the Idaho contributing project, crossbred Panama x Traghee lambs were heavier at weaning than comparable purebred lambs of the two parental breeds.

Regional Project S-29

In the Southern region, cooperative research in sheep breeding and reproductive physiology is conducted under regional project S-29, Genetic and Physiological Factors Affecting Reproduction of Sheep in the South. Contributing projects from eight States are concerned directly with improvement of sheep through breeding. Other work on S-29 is included in the section on physiology. New projects were approved for the Florida and Mississippi stations, and the Arkansas and Virginia contributing projects were extensively revised during the year.

Cooperation among the States and stations has increased, particularly in exchange and distribution of breeding animals. Alabama, Florida, and Tennessee have initiated a cooperative project to study the reproductive performance of the Rambouillet ewe under different environments. Random samples of Rambouillet ewes of the same genetic background were obtained from a Texas substation and distributed to the three States. Observations will be made on various reproductive and production phenomena at each location. An exchange of parts of breeding flocks between the Experiment (in the Piedmont) and Blairsville (mountain) stations in Georgia resulted in significant genotype x station interactions for date of lambing. Rams, progeny tested in Virginia and Arkansas, were transferred to the McGregor, Texas, station for further progeny testing. A similar arrangement was made in 1961 between the Virginia and South Carolina stations. These should provide useful information on the importance of sire x location-year interactions.

Comparisons of different breeds and breed crosses at several stations over a number of years have provided valuable information on adaptation of different genotypes to particular environmental conditions. Grade Rambouillet ewes have been found superior in terms of early lambing (before January 1) to crossbreds of Columbia, Suffolk or Hampshire by Rambouillet at the Alabama station. The crossbred ewes were somewhat more prolific, however, and produced somewhat higher grading lambs as well as heavier fleeces. Grade Rambouillet ewes were superior to Targhees, particularly in early lambing, at the Alabama Piedmont station.

Breed comparisons at the Florida station among Hampshire, Rambouillet and Florida Native ewes indicated that Hampshires were not suited to Florida climatic and environmental conditions. The Florida Native ewes were about a week later in date of first estrus than the Rambouillets but required fewer services per conception and therefore averaged about a week earlier in lambing date. Lambs from the Rambouillet ewes were heavier at weaning and graded higher, however.

The Tennessee station has found that crossbred ewes, Suffolk x Rambouillet or the 3 breed cross Hampshire x Suffolk x Rambouillet, lamb about 2 weeks earlier than grade Hampshires. Rambouillet ewes lambed as early as the crossbreds but had fewer twins. A larger proportion of their lambs born were raised to weaning, however. Preliminary results from the Athens, Georgia, station indicate that crossbred Dorset or Suffolk by Rambouillet ewes have satisfactory reproductive performance under their conditions. At the Texas station lambs sired by Columbia, Suffolk, or Hampshire rams out of fine wool ewes had heavier weaning weights and higher slaughter grades than Rambouillet sired lambs.

Long term breeding projects to study the effectiveness of several methods of selection and mating systems are in progress at the Arkansas, Kentucky, and Virginia stations. These projects are in only the first or second generation, so that conclusive results are not available. A number of inbred lines of Hampshires and Suffolks have been established at the Arkansas station. Divergence of these lines in a number of characteristics, including proportion of early lambing and resistance to internal parasites, is indicated. Some line crossing has been done and breeding tests of inbred and line cross rams initiated. Improvement of summer fertility in Southdown rams through selection on semen quality and earliness of lambing is being attempted at the Kentucky station. So far selection has been possible only in the rams, and results of the first 5 years are inconclusive.

Methods of selection for rapid growth rate of lambs from birth to weaning are being studied at the Virginia station. Flocks selected

on the basis of progeny tests are compared with mass selection and with a control flock bred by random selection. Results to date do not warrant conclusions; however, rather large differences among progeny of randomly selected rams have been observed.

Other Research

In addition to the regional research effort considerable other research progress in sheep breeding has been accomplished both cooperatively and by State stations individually.

At the Utah station productivity of Columbia, Targhee and Rambouillet ewes raising purebred and crossbred lambs was assessed. Yield per ewe ranged from 106.7 #lamb for dams of Columbia-Targhee lambs to 75.4 #lamb for dams of Rambouillet-Columbia lambs. Death losses of lambs ranged from 23% in the Rambouillet-Columbia lambs to 6% in the Columbia-Rambouillet lambs.

At Colorado, selection for weaning weight alone, for staple length alone or for an index based on both staple length and weaning weight resulted in greatest increase in weaning weight from the index basis and greatest increase in staple length from the staple length selection with the index being nearly as effective. Heritability estimates were 0.35 for weaning weight, 0.72 for staple length and .33 for index.

Working cooperatively the Redd ranches, the Utah and Colorado experiment stations and the USDA have set up selection flocks in the Redd sheep band which are now 10% more productive than unselected flocks. A superior wool flock has been established which is 10 - 20% more productive than other flocks and is used as the source of replacement ewes and rams.

The effects of sire, sex, type of raising, age of dam, year and age at weaning upon the weaning weight of Suffolk lambs were studied at Idaho. Type of raising had the greatest influence upon weaning weight, with singles averaging from 8.84 to 18.96 pounds heavier than twins. During most years, ram lambs were significantly heavier than ewe lambs. The effect of age at weaning upon average weaning weight ranged from .19 to .67 pounds for each day difference in weaning age. The effect of year upon weaning weights was significant. There was a tendency for the 2-year-old ewes and the oldest ewes to wean lighter lambs than the 4- and 5-year-old ewes. Sire had relatively little influence upon the weaning weight of the lambs, and in no case was sire effect significant.

At the Montana station, matings for inbred lines of Rambouillet have continued and six years of top crossing is now being analyzed in cooperation with the USDA station at Dubois, Idaho. Detailed results of this work are given in the USDA report.

At the New Mexico station, lifetime records of wool yield and body weight indicate these traits are fairly repeatable (.50). However, selection based on weights taken each year (rather than only once) increased the selection differential about 50% for fleece weight and 30% for growth and would increase therefore the possible gain from selection. Also at the New Mexico station selection differentials for seven wool and growth traits of yearling fine wool ewes were calculated when the top 40% of ewes were selected on the basis of a single trait. The selection trial repeated for each of three other traits. Positive selection differentials were obtained in most cases for all seven traits but the greatest selection differential for a trait was obtained when selection was based on the trait. Selection for one trait was relatively inefficient in getting differentials for other traits.

Inbred lines of Columbia and Corriedale sheep have been developed through selection at the Wyoming station but great diversity between lines in measured traits within breeds has not been achieved. In the Columbia lines particularly, differences in appearance are noted. Selection in a flock of Columbias at the Wyoming station has resulted in marked extension of brown pigment. Offspring with brown markings occur more frequently when both parents have brown than when one parent lacks the brown pigment. Despite great yearly variation in color, attempts to demonstrate a nutritional effect on color have been unsuccessful.

At the Oregon station effects of inbreeding in sheep were studied. Birth weights of single lambs were more adversely affected than those of twin lambs. Similarly inbreeding produced greater depression in some breeding groups than in others apparently depending on the genetic constitution of the group or line.

At the California station, work on blood typing of sheep is being conducted cooperatively with the USDA. This work fits in well with the California research program of blood groups in other species, particularly cattle.

At the Sonora (Texas) substation, comparative efficiency of visual culling versus selection on an index for grease fleece weight and staple length is getting well underway with apparent greater progress being made for each trait when selection is based on the index for performance. Heritability estimates of weaning weight of Rambouillet lambs was 13.8% using unadjusted weaning weight and the

method of intrasire regression of offspring on dam. Adjustment of weaning weight of lambs for age of dam, type of birth and age of lamb resulted in an increase of calculated heritability of weaning weight to .25. The half-sib correlation method yielded heritability estimates considerable higher but these estimates were quite erratic.

Heritability estimates of gain were made from crossbred milk lambs at the Oklahoma station using both average daily gain and weight per day of age. Heritability was least from birth to 50 pounds (about .10) and about .35 from 50 to 90 pounds. There was little difference between using average daily gain or weight per day of age.

Workers at the Arkansas station have shown significant effects of type of rearing and age of dam upon the weaning weights of lambs of mutton breeds. Inbreeding of the lambs appeared to depress growth but the decline was not significant. Crossbred lambs raised at a branch station in Arkansas also reflected differences in growth rate to weaning due to type of rearing (singles versus twins), age of dam, and date of birth.

A flock of Hampshire ewes of Mt. Haggin breeding has been assembled at the Louisiana station and rams of various sources are being evaluated on progeny performance in the production of meat-type lambs.

Productive efficiency of existing early lambing flocks in Mississippi is currently being studied with the purpose of establishing a line of early lambing, high quality mutton sheep for Mississippi conditions. Flocks at two locations show characteristics of both early lambing and heavy weaning, high grading lambs.

West Virginia has demonstrated differences between rams within breeds and between mutton breeds of rams in their ability to produce fast gaining, high grading fat lambs.

At the Vermont station cooperative research activity with the USDA is being directed toward the development of a breed of sheep producing a desirable meat type lamb and a maximum of high quality 3/8 and 1/4 blood wool. This strain is of Columbia-Southdale origin and has been compared with the Columbia breed in experimental trials.

Wisconsin workers have compared the productivity of grade Hampshire ewes in farm flocks when bred to rams of four breeds--Hampshire, Suffolk, Corriedale, and Columbia. Lambs from Corriedale rams were several pounds lighter at weaning and lower in grade than other progeny groups. Ewe lambs were lighter than wethers but excelled in length

of fleece. Single lambs were heavier than twins and were better in fleece length. Carcasses of Suffolk-sired lambs were heaviest while lambs from Hampshire and Correidale rams had higher grading carcasses. Preliminary evidence indicates that the crossbred ewes excelled grade Hampshire ewes in combination of wool and lamb production.

At the Missouri station, progeny of four outstanding Hampshire rams showed significant sire differences for birth weight, weaning weight, wool weight and for carcass traits including untrimmed leg, untrimmed shoulder, and trimmed shoulder. Differences due to sires in area of loin eye, efficiency of gain, and trimmed rack approached statistical significance. Differences in rate of gain between sire progenies were not significant.

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B. PHYSIOLOGY

PROBLEM

Efficient reproduction and growth are essential to economical and competitive production of sheep and wool. Additional information is needed regarding the basic physiological processes involved in reproduction and growth. There is also need to more accurately assess the effects of various environmental stresses on production.

PROGRAM OF THE STATE EXPERIMENT STATIONS

Primary emphasis in research on sheep physiology at the State Agricultural Experiment Stations is directed to reproductive physiology (3.9 professional man-years). Studies are underway to determine the endocrine shifts responsible for the seasonal breeding behavior of sheep and means of altering it. 2.3 professional man-years are engaged in determining the effects of stresses of nutrient restriction, altitude and temperature on growth and productivity of sheep, and 1.8 professional man-years are devoted to studying the physiology of growth and development.

RELATED PROGRAMS OF THE USDA

Research by USDA in this area totals 3.7 professional man-years. Of this number 1.7 are devoted to physiology of reproduction, 0.1 to environmental physiology, 1.5 to physiology of wool and fibers, and 0.4 to program leadership.

PROGRESS OF STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

The California station is studying the hormonal control of reproductive process in sheep. Results from this study show that antiserum against human chorionic gonadotrophin and against pituitary follicle stimulating hormone synergize with each other in the rat and in the ewe in inhibiting ovarian activity. Resumption of the cycle in the ewe following cessation of treatment has been sporadic. Bioassay of plasma from blood which drains the pituitary directly has shown a high concentration of both FSH and ICSH activity as well as growth hormone. This is the first demonstration of pituitary gonadotrophic and growth hormone activity in the blood of sheep. Other studies clearly indicate an important relationship between the hypothalamus and reproductive activity in both male and female sheep by the neural control of gonadotrophic secretion. This relationship offers a partial explanation for the photoperiodic pattern of reproductive activity in the ewe. To elucidate the nervous pathways over which the light stimuli, which cause this photoperiodic effect, are transmitted, the optic nerves of four ewes were severed and in three

animals an area of the posterior optic chiasm was destroyed. Cyclical reproductive activity has been inhibited but not completely abolished as a result of these operations.

The Missouri station has nearly completed a comparative study of the lipoprotein carbohydrate complex in mature and immature spermatozoa showing that these cells differ in the manner the complex is bound in the cell and in lipid content. Methods have been developed and work begun on the characterization of sperm histones. Research on nucleic acids (DNA) show that immature and mature spermatozoa contain similar types but that the proteins are more tightly bound to the DNA of mature sperm than that of immature spermatozoa. New methods for the isolation and purification of DNA have been developed.

Results of work at the Texas station indicate that the state of lactation should determine the type of treatment for hormonal induction of post-partum estrus. It was observed that a deficiency of gonadotropic hormones and very small pale reproductive tracts exist in lactating ewes. As lactation declines the size of the ovaries and uterus increase. Ewes injected early in lactation require twice the amount of PMS to cause ovulation than at 35 days.

The Wisconsin station has conducted a basic study on the physiology of flushing. Results indicate that the underlying mechanism involved in flushing of ewes suggests it may be a result of increased protein synthesis in the animal. Stimulation of the animal's metabolism with insulin under conditions of sugar administration produced marked stimulation of ovarian activity. Administration of thyroid hormone did not prove beneficial. Thyroid hormone administration resulted in prolonged estrual cycles and maintenance of corpora lutea in some animals.

Research in artificial estrus control is progessing most satisfactorily.

The New York (Cornell) station conducted a trial with 120 ewes in which 40 ewes were fed 6-methyl-17-acetoxy-progesterone as a means of synchronizing estrus. Thirty-seven of the 40 showed estrus within a 12-hour period. Eighteen were bred artificially and 17 naturally. Forty ewes were allowed to cycle normally and bred naturally and 40 allowed to cycle normally and bred artificially. All artificial breedings were made with raw semen. The percent of ewes lambing in each group were: normal estrus-naturally bred, 50%; normal estrus-artificially bred, 49%; synchronized estrus-naturally bred, 61%; synchronized estrus-artificially bred, 16%. The rams used varied in fertility from 26 to 74%.

At the South Dakota station orally active progestational compound was fed to synchronize estrus and stimulate fertile estrus in the anestrous ewe. 98 ewes were fed 4 levels (1, 2, 3 and 4 mg./ewe/day) followed by 1000 I.U. PMS and half of each group received 500 mcg. of estradiol. Ewes fed 1 and 2 mg. had the highest incidence of heat, 40 of 49, and the 3 and 4 mg. group 36 of 49. All ewes came in heat within a 2-day period (80% on the same day). These ewes were bred to fertile rams and allowed to go to term. The best results were obtained from ewes fed 1 mg.

At the Wyoming station 81 Rambouillet and Columbia ewes were fed 6-methyl-17-acetoxyprogesterone in groups of 12, 29, and 40. Estrus was synchronized by feeding 120 mg./ewe/day in 1/2 lb. grain once daily for 13 days. Ewes began coming into heat about 48 hours after the last feeding. Of the 81 ewes, 75 were marked on the 3rd, 4th, and 5th days post-feeding. Lambings were concentrated in 7- to 8-day periods, separated by a 7- to 10-day period during which only a few ewes lambed. Lamb numbers were normal and were equal to controlled comparisons. Conception rate appeared to depend upon the capacity of the ram. It would appear that 12 ewes per ram is optimum.

The Illinois station continued its investigations to define the minimal effective level of Provera (The Upjohn Co.) as an orally administered progestin. Twenty ewes each at 0, 25, 50, and 75 mg./ head/day were individually fed 14 days with records on individual consumption, ambient temperature and raddlemarks being made. Upon the withdrawal of the progestin, the breeding activity of treated ewes was grouped within the first 124 hours following withdrawal. Lambing records suggest that lambings were grouped in the treated ewes. 75 treated and 25 control ewes were used in a group feeding situation to determine whether 50 mg. per head per day of progestin would synchronize estrus. Raddlemarks collected at breeding and subsequent lambings indicate some degree of success in synchronization. Under a group feeding situation involving 69 ewes, 75 mg. per head per day did not result in as satisfactory grouping as ewes receiving 50 mg.

The effect of various pastures on the breeding efficiency of sheep was studied at the Illinois station. Three pasture species were represented -- ladino, Korean lespedeza, and orchardgrass. Performance of the ewes in the breeding and lambing season suggest improved conception and lambing rates for ewes grazing ladino pastures either throughout the grazing season or only during flushing and breeding. Lespedeza was slightly superior to orchardgrass. It, therefore, appears that grass "maintenance" pastures may be effectively used prior to flushing and breeding if ewes are flushed on ladino.

The Kentucky station also studied the effectiveness of Provera in synchronizing estrus and time of lambing in ewes. 38 of 40 ewes

returned to estrus 2 to 5 days after Provera feeding ended. Variance in time of onset of estrus was reduced from 18.3 to 0.6 for pretreatment and post-treatment estrus respectively. 16 out of 19 ewes lambed within a 7-day period to the first post-treatment breeding.

Eleven States in the Southern region and USDA are cooperating in a study of the genetic and physiological factors affecting reproduction of sheep in the South. The North Carolina station is studying the effect of ambient temperature upon early embryo loss in sheep. Sheep ova recovered just prior to ovulation could not be transferred and/or fertilized in the host. When transferred immediately after ovulation fertilization does occur. The use of this technique on 21 ova suggest that ambient temperatures of 90°F. is harmful both before and after fertilization. To test the inherent fertility of these sheep, none of seven ewes kept at 90°F. temperature maintained embryos for 30 days as compared to 6 out of 8 kept at 70°F. The effect of short periods of high ambient temperature on the intact bred ewe was continued. Ewes subjected to temperatures of 90°F. until mating then placed in temperatures of 70°F. for 4 to 5 days produced the greatest number of lambs. Observations made on ewes shifted between temperatures at other times present a confused picture. It appears that the physiological mechanism responsible involves varying degrees of embryonic susceptibility to high temperatures.

At the Georgia station PMS treatments, compared with controls, increased the percent lamb crop -- in other words, lambs born and lambs living in 48 hours after birth -- of both groups of ewes at two locations. Contrary to previous years' results, cooled ewes at one location showed no improvement in lamb crop as compared with non-cooled ewes.

Data from six lamb crops at the South Carolina station indicate that sexual activity is influenced by light and temperature. Data also suggest that the breeding seasons can be controlled most effectively by a combination of light and temperature. From this data it appears that by controlling light and temperature the breeding season and consequently the lambing period can be changed to suit local conditions.

At the Mississippi station, groups of ewes were cooled for 6 days before, 6 days after, and 6 days before and after breeding. There appeared to be a trend for cooling after breeding to be beneficial.

Ten States in the Western region and the USDA are cooperating in a study of the effects of environmental stresses on range cattle and sheep production.

The Colorado station is studying the effect of altitude on cattle, sheep, and rat blood with emphasis on iron and hemoglobin content, color density and hemoglobin composition. Elevation was effective on the responses of certain organs, especially those having to do with blood storage or movement such as the liver, heart and kidney. Changes observed were hypertrophy, increase in weight, and also the development of fibrosis in the case of the liver, at higher altitudes. Isolation of pure, crystalline hemoglobin has led to the finding that the iron content of the hemoglobin molecule is considerably different than the value given in the published literature. This was observed not only on pooled cattle and sheep bloods, but also on individual rat, cattle and sheep bloods collected at different altitudes and seasons. Values obtained to date range from 0.091 to 0.378 percent, in contrast to the constant value of 0.335 reported in the literature.

At the Utah station 36 individually fed ewes that have been on experiment since January 1958 were carried through the fourth gestation period and slaughtered shortly after lambing. The phases of this study related to the protein differentials, e.g., body weight changes, lamb production, body composition, four digestibility and balance studies on all ewes, and periodic wool diameter studies are being summarized. In another study 24 sheep were paired by weight and allotted to two groups. One group was maintained in a temperature range of 17-49°F, and the other group was maintained in a warmer temperature of 66-78°F. When watered every day the sheep in the warmer temperature drank 12.5 pounds of water per day as compared to 8.7 pounds for the sheep in the cool temperature. The average feed consumption was 4.2 pounds of meadow hay per day for both groups. When watered on alternate days the water consumption in the cool location was 5.6 pounds per day, and 7.4 in the warm location. Four winters of individual feeding of ewes indicates that weight fluctuations in range ewes during periods of climatic stress is an effect of reduced feed intake rather than any direct effect of climate.

The Arizona station studied the influence of ambient temperature on the efficiency of carotene utilization in sheep. Total hepatic vitamin A was used to determine the effect of high (100°F.) and moderate (70°F.) ambient temperatures on the efficiency of conversion of carotene to vitamin A. Data from this study show that even after a 12-month depletion period the animals still had appreciable stores of hepatic vitamin A. There was a great deal of variation among the animals, but in all instances the values were above what would be considered complete depletion. After four weeks of intraruminal injections of Beta carotene, the liver analysis showed a decreased vitamin A content. Hematocrit, plasma vitamin A, total serum protein and serum protein fractions did not show any definite trend or change that could be attributed to treatment effect.

At the Montana station reproductive data for flushed and control ewes respectively were as follows: Ovulation rate 1.55 vs. 1.18; fertilization rate 80% vs. 92%; recovery rates of ova 89% vs. 96%; percent abnormal ova 44% vs. 32%. The same information comparing 2-year-old ewes with mature ewes respectively is as follows: Ovulation rate 1.20 vs. 1.44; fertilization rate 100% vs. 79%; percent of abnormal ova 31% vs. 41%; and recovery rate of ova 89% vs. 94%. The percent of abnormal ova was considerably higher than other years, previously being in the neighborhood of 5 to 15 percent. The mean for 1961 was 38 percent, the majority occurring during a 3-day cold spell (-30°F.). During this period 59% of all ova recovered were abnormal.

At the Wyoming station the pounds of lamb weaned per ewe was significantly related to nutritional regime during gestation. Some of the detrimental effects of nutritional stress can be alleviated by increasing the plane of nutrition during the last one-third of pregnancy.

At the Hawaii station a flock of Targhee sheep continues to show evidence of heat stress. Above normal rectal temperatures and labored breathing were recorded. A very small lamb crop (39% at birth) was attributed to environmental stress. In a cooperative study with a commercial ranch, Targhee topcross lambs were significantly heavier than the commercial ranch lambs.

Environmental stress studies at the Kentucky station indicate that ova from ewes exposed to heat stress are capable of fertilization and developing into normal embryos, if the heat stress is removed at time of breeding. Fertilization rate was above 90% for crossbred ewes placed in a hot room at 90°F., relative humidity 60%, on the twelfth day of the cycle before breeding, and removed four days later, or at time of breeding. Eighty percent of the ewes lambed.

The Kansas station studied the effects of forced exercise and various methods of cooling ewes during early gestation on subsequent reproductive performance. Results in the summer of 1961 did not show the same advantage on embryo survival for air conditioning as was found in 1960. Forced exercise again appeared detrimental for maximum 3-day fertilization rate.

Three experiments were conducted at the Missouri station to test the effects of a combination of environmental temperature and thyroxine therapy on the semen quality of a group of thirteen Hampshire rams. It was determined that temperatures of approximately 80°F. caused a marked decline in apparent fertility. The daily injection of 0.2, 0.3, or 0.4 mg. L-thyroxine per 100 lb. body weight did not significantly affect semen quality. It was observed, however, that thyroxine

administration at temperatures above 80°F. appeared to accentuate the decline in apparent fertility. In two trials involving 26 rams of mixed breeding, neither goitrogenic inhibition of the thyroid nor surgical thyroidectomy were found to influence semen quality.

The Missouri station has been conducting a very basic study on the factors affecting the cerebral circulation of sheep. It was concluded that arterial blood is supplied to the brain from the internal maxillary artery by way of the rete mirabile, the superior sagittal sinus is the only place from which to collect pure cerebral venous blood and that by virtue of its strategic location, further investigation of the function of the carotid rete mirabile is necessary. Progress was made in the adaptation of the nitrous oxide method for use in sheep. An initial experiment was performed to determine the observable effects of intracarotid infusion of various drugs.

The Colorado station is studying the effects of age on fleece traits and body weight of rams. Data have been taken on 400-700 ram lambs and 100-300 yearling and mature rams at shearing since the project began in 1958. A least squares analysis of the data will be made when the ram lambs originally selected have been in the ram flock for five years.

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C. NUTRITION AND MANAGEMENT

PROBLEM

The greatest single expense factor in sheep and wool production is the cost of the feed used. As competing industries become more efficient and thereby lower their costs, so also must the sheep industry if it is to compete successfully. This requires continuing research on improved methods of feeding. Refinement of knowledge of the basic nutritional requirements, metabolism of nutrients, and metabolic and/or nutritional diseases of sheep provide the broad base upon which better feeding practices are built. The success or failure of sheep enterprises depends very heavily upon the production practices used. Better methods are needed for reduction of lamb mortality and disease and parasite losses; for handling ewes during breeding, gestation and lactation to increase productivity; and for labor saving devices or procedures to increase the efficiency of the operation.

PROGRAM OF THE STATE EXPERIMENT STATIONS

The research underway at the various State agricultural experiment stations covers the broad range of problems in sheep nutrition and management. The total effort of the State stations in fiscal 1962 consisted of 23 professional man years.

In addition there are numerous projects being conducted at the various State stations which are concerned with forage quality and with the metabolism of specific nutrients in which there is only an indirect application to sheep production. Many of these projects are developing principles which have application to sheep because they apply to ruminants in general or because they apply to both ruminants and monogastric animals. No attempt has been made to include all of these projects.

A group of projects, without mention of which a report such as this would be quite incomplete, consists of several regional projects in which the work has more or less application to sheep production depending on the nature of the individual state projects contributing to them. Some are aimed directly to sheep production, in others sheep are used as useful research tools, in others the results have application to ruminants in general. The title, objectives and number of states cooperating on each of these is as follows:

NC-25, Factors Affecting the Utilization of Feed by Ruminants.

Objective: To improve the utilization of roughages by ruminants with emphasis upon the utilization of the carbohydrate fraction.

12 North Central States and the USDA cooperating.

NC-27, Chemistry and Physiology of Bloat.

Objectives: 1. To determine the physical and chemical characteristics of bloat provoking feeds and other substances. 2. To determine the physical and chemical differences of ruminal digesta during digestion in normal and bloated animals. 3. To study the physiologic responses of ruminants to bloat. 4. To develop and elucidate measures for the control of bloat.

9 North Central States and the USDA cooperating.

NE-24, The Nutritive Evaluation of Forages.

Objectives: 1. To evaluate various forages grown under known conditions and harvested at specific dates and stages of maturity by determining digestible protein and digestible energy. 2. To develop methods for the nutritive evaluation of forages - these to include the use of biological and chemical techniques. 3. To conduct supplementary animal production and voluntary consumption trials insofar as possible.

11 Northeastern States and the USDA cooperating.

S-45, Nutritional Evaluation of Forage Crops.

Objectives: 1. To determine chemical and physical properties of forages that are related to animal response. 2. To develop methods for predicting nutritional value of forage crops under known intake conditions. 3. To develop methods for measuring intake and digestibility of grazed forages. 4. To develop methods for predicting forage intake.

6 Southern States and the USDA cooperating.

W-34, Range Livestock Nutrition.

Objectives: 1. To improve techniques for measuring qualitative and quantitative forage intake of range animals and range forage digestibility. 2. To determine the energy, protein and phosphorus requirements of beef cattle and sheep compatible with optimum production on the Western Range.

12 Western States and the USDA cooperating.

For purposes of discussion, the program has been divided into the following six areas:

1. Feeds and Their Physical Form. The availability of feed constituents; the nutritional value of pastures, range and harvested forages; the development of indirect methods for measurement of forage utilization and/or forage value; the effect of ration physical form on ruminant digestion; physiologically active constituents of forages; utilizing fermented grains; the effect of purified food ingredients for ration supplementation and for determining nutrient requirements; and creep rations for lambs.

2. Rumen Function. Rumen development; improving rumen function; carbohydrate and nitrogen metabolism; rumen microbiology and metabolism of microbial products.

3. Metabolic and Nutritional Disorders. Grass tetany, white muscle disease, urinary calculi; bloat; metabolism of fission products; and effect of yeast supplementation on ability to withstand irradiation (using rats,but screening for cattle, swine and sheep).

4. Mineral Studies. The requirements for and interrelations concerning calcium, phosphorus, magnesium, zinc, molybdenum, iron, potassium, selenium, cation-anion relationships, and ammonia toxicity in grass tetany.

5. Feed Additives and Implants. Growth promotants; effect of hormones on growth and fattening.

6. General Nutrition. Effect of nutrient restriction on growth and body composition; energy and protein requirements on range; nutrient requirements of range livestock; evaluation of grazing (range) animals diet; nutritional requirements of pregnant and lactating ewes and their lambs; lamb fattening; effect of vitamins on growth and reproduction; essentials of the ruminant diet; and economics of forage and livestock production.

7. Management.

RELATED PROGRAMS OF USDA.

The USDA scientific effort devoted to research in this area totals 3.3 professional man-years. Of this number 1.1 are devoted to digestion and metabolism, 0.5 to forage evaluation and utilization, 1.6 to range and pasture management, and 0.1 to management practices, equipment and facilities.

PROGRESS OF STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

Feeds and Their Physical Form

In Florida a dried citrus pulp was compared with ground snapped corn, both at 66% of the ration, as a feed for lambs. The results were inconclusive in that in the first summer there was no difference in grains but in the second, a significant advantage to corn. In the same project, use of an enzyme preparation containing protease, amylase and gumase activity increased digestibility of nitrogen-free-extract in citrus pulp, but not tomato pulp. In neither case was the total energy utilization improved.

North Dakota has shown that feed residues and digestibility indicators do not move through the various portions of the sheep digestive tract at the same rates; therefore, in digestive studies involving the contributions of various sections of the digestive tract no one indicator is best for all sections.

In the Western region, Montana has been using sheep equipped with esophageal fistulas to determine the quantity and quality of the diet of range sheep. The Utah station reported that introduced wheatgrasses produced better livestock gains than native foothill range.

The effect of level of feed intake upon digestibility was shown by Pennsylvania to vary with different hays; with pelleted Reed canarygrass there was a significant reduction with an increase in intake, but there was no such effect with pelleted alfalfa.

The effect of added fat upon forage utilization is being investigated by the Arizona station; alfalfa plus 5% added tallow resulted in a slight increase in food intake with essentially the same coefficient of digestibility of dry matter.

At Arkansas some areas of the state in which forages are deficient in cobalt, copper and zinc have been identified. Digestibility and blood hemoglobin levels were increased by mineral supplementation in those areas. The use of winter wheat pastures prior to lambing was shown to increase the birth weight of the lambs.

That purebred ewes and crossbred ewes differed in plant species preference was shown in Kentucky. Creep feeding of lambs resulted in greater gains than when not creep fed. Cracked corn and a complex creep mixture were both superior to shelled corn or pelleted corn as creep feeds. Also at this station the relation of the buffering capacity of saliva to feed utilization when sheep are fed different types of rations is under study. Results are suggestive of

differences but are inconclusive.

The effect of flushing ewes on pasture upon the twinning rate may be due to physiologically active constituents in the forage rather than, or in addition to, the effect of weight gain alone (Ohio). In another study forage crop silage preserved by additions of grain when fed to pregnant ewes resulted in higher condition of the ewes, but did not affect milk production as indicated by lamb weight.

The Texas station has made chemical analyses and determined animal digestibilities of Gulf ryegrass harvested at various stages of maturity. These data are being searched for plant factors that will predict animal response on that forage.

The New Mexico, Ohio, and South Dakota stations have all indicated successful use of artificial rumen techniques in studies of forage quality correlated with animal performance.

The TDN predicted from percent nitrogen and percent crude fiber did not correlate well with sheep digestion in Missouri work.

The Cornell station is working on methods of measuring energy deposit in body tissues in order to measure the productive energy of feeds. Good estimates were obtained using a combination of compounds, one of which is dispersed throughout the water in the body and one which does not pass significantly into water in the digestive tract content.

In California sheep were satisfactorily fattened on a high concentrate-low roughage ration. The degree of rumen parakeratosis was influenced by the fineness of grind of hay in pelleted rations.

In Missouri work, the pelleting of highly digestible feeds had little effect upon digestibility, but pelleting low quality roughages resulted in considerable improvement in both intake and digestibility. There are apparently some changes in the forage other than purely physical ones which reduce the apparent fiber level and increase the utilization.

Corn, barley, rye, wheat and sorghum gains were compared in Kansas as the grain portion of completely pelleted rations. Unpelleted rations produced the slowest, but cheapest gains. The wheat rations produced the fastest, most efficient and most expensive gains. There were no significant differences in efficiency among the other four grains.

Results of work in Alabama appear to indicate that a as yet undefined, nutrient imbalance exists in certain local forages that results in poor growth of animals fed these forages.

At the Missouri station it has been shown that urea-nitrate combinations cause a greater distribution of nitrate in the animal than without the urea. Nitrite was shown to oxidize carotene and vitamin A in vitro. These studies lend support to a need for vitamin A supplementation when rations high in nitrate are being fed.

Alaska workers have shown that wet grains can be successfully stored as silage and this can be a satisfactory emergency measure during wet harvest seasons.

Rumen Function

Some factors concerned in rumen development have been reported by Indiana and Cornell workers. The Indiana work has indicated a reduction in the oxidation of volatile fatty acids (VFA) by rumen epithelium after 70-80 days on a fattening ration compared to 25-35 days, and a negative correlation between the rate of oxidation of VFA by rumen epithelium and the rate of gain. There was also a significant correlation between the length of the rumen papillae and the gain in weight of lambs.

The Cornell work has pointed out that the rumen is very responsive, expanding and contracting as needed; and that with young animals fed long hay eating stops when the rumen is full, but with pelleted hay eating stops before the rumen is filled, which indicates that factors other than fill are also concerned in determining levels of feed intake.

California workers in cooperation with ARS have reported a low acid-CO_2 ratio in manometric experiments in which alfalfa hay is fermented by rumen microorganisms. Three factors appear to cause this effect: the dicarboxylic acids and amino acids in the water soluble fraction and ammonium hydroxide soluble material in the hemicellulose.

The utilization of phosphorus (P) by rumen bacteria was shown to be dependent upon the source of P in Tennessee studies; that from three dicalcium phosphates was equally available but with defluorinated phosphates some were highly available, some completely unavailable, and others ranging in between. Other findings indicate a considerable variation in microbial activity with variations in feed quality.

The Maryland station has reported that the concentrations of rumen VFA reflected the quantities of feed consumed. The ratio of acetate to propionate was higher on an early head sudan grass hay than on older sudan grass or mature orchard grass hays. Indiana work indicates that one effect of antibiotics upon rumen fermentation is to induce a greater acetate to propionate ratio when cellulose is fermented. These workers also reported that when casein was fed the production of propionate was greater than when urea or ammonium citrate were fed.

Iowa workers have demonstrated that rumen fermentation involving digestion of fibrous feeds depends upon the presence of adequate nutrients needed by the microorganisms. The nutrients include readily available energy, protein or ammonia nitrogen, major and minor minerals and some unidentified factors.

To develop an understanding of the metabolism of carbohydrates in the rumen: Iowa workers have concentrated largely on methodology in culturing large enough cultures of pure strains of rumen organisms to be used in a continuous flow apparatus. Good progress has been made. Texas station workers are presently working mainly on methods for carbohydrate study. They are working on carbohydrate analysis techniques which will permit quantification of the rates and quantities of individual carbohydrates fermented. This work is also progressing well. Pennsylvania workers indicated a depressing effect of added glucose or starch upon cellulose digestion which did not appear to be due to pH or limiting nutrients.

The metabolism of nitrogenous products in the rumen is being studied at the following stations: 1. Kansas - The rumen amino acid concentration was higher for each amino acid studied when soybean protein was fed than when urea was the nitrogen source. 2. Missouri - Frequent feeding of urea results in better utilization of the fed urea than less frequent feeding. Nitrate additions reduced the utilization of urea and interfered with iodine metabolism of the thyroid gland. 3. Nebraska - When casein is fed to ruminants, rumen ammonia concentration rises more than when most other proteins are fed. Calculations of the amide content of casein indicates this may be the source of about one-half of the ammonia; the remainder may be due to slow deamination of the amino acid mixture resulting when casein is hydrolyzed. 4. South Dakota - Using radioactive sulfur as a tracer it was shown that inorganic sulfur can be incorporated into protein in the rumen. In this work no evidence was observed of an effect of nitrate upon carotene and vitamin A levels of the blood. 5. West Virginia - These workers have demonstrated some of the enzymes (glutamic dehydrogenase and transaminase) of the rumen mucosa that are apparently concerned with nitrogen metabolism in the ruminant animal. There was no apparent increase in the ability to utilize urea as a result of

feeding these enzymes.

The North Dakota station is making good progress securing pure cultures of rumen organisms and determining the role each plays in feed utilization.

The Illinois, Cornell and Virginia stations each are making important contributions to an understanding of the pathways of nutrient metabolism in the rumen.

Metabolic and/or Nutritional Disorders

In pilot work using laboratory animals, the effect of dietary factors in protecting against gamma irradiation is being investigated in Florida (The project title indicates that the species of interest here are cattle, swine and sheep). Vitamin A appeared to have some protective effect while citric acid, although stimulating growth, had no effect of irradiation protection.

Tennessee, in cooperation with the Atomic Energy Commission, has reported studies of the absorption and metabolism of the radio-isotope Cerium 144 in sheep. There was no measurable absorption from the digestive tract. Intravenous injection resulted in very little excretion in the feces and urine with most of the dose accumulating in the liver.

In Mississippi studies, low total nitrogen in the forage appears to be associated with the occurrence of "grass tetany". West Virginia work in this area indicates that there is a spectrum of diseases involving in many cases both calcium and magnesium.

In recent years it has been demonstrated in several species that selenium and vitamin E are involved in nutritional white muscle disease. Because ration supplementation with selenium is becoming a common practice, the Wyoming station, in cooperation with the Atomic Energy Commission, is investigating the effects of chronic toxic doses. Repeated injection of toxic amounts of selenium interfers with cellular function and with placental transmission. Nevada and South Carolina are relating the composition of feeds and the animal body to the problem in their respective areas. Wisconsin has studies under way on the relative merits of vitamin E and selenium in preventing this condition.

The role of dietary factors in the occurrence of urinary calculi is under investigation in Indiana. It is well known that some rations cause much more trouble than others. The specific factors responsible are largely unknown. The importance of urinary mucoproteins in formation of the organic matrix found in uroliths is a subject of study in California.

The occurrence of bloat is a problem in ruminant feeding throughout the nation both in feedlot and pasture feeding. The regional project NC-27, Chemistry and Physiology of Bloat, is concerned with this problem in domestic ruminants. Nine state stations and the Animal Husbandry Division of ARS, USDA, are cooperating in this regional project. Only four of these projects have specific application to sheep, however, all are concerned with ruminants in general which includes sheep. Iowa work has shown some of the important nutritional and microbiological relationships in bloat and has demonstrated that bloat can be controlled for extended periods of time by daily oral administration of a combination of antibiotics. Ohio, results indicate that acid soluble pectic substances may be important in bloat. Minnesota and Missouri workers are investigating the physiology of bloating animals. Minnesota: In experimentally bloated animals there is an increase in venous pressure and in venous blood glucose concentration. The Missouri work is just getting well started.

The North Carolina work last year pointed out that restricted grazing time can be a useful management practice in bloat control.

California workers published an intensive study of physiological differences between bloat susceptible and non-susceptible animals. Results last year indicate that, contrary to expectation, the frequency of mixing and eructation contractions of the rumen were greater during and following the feeding of alfalfa tops than during and following the feeding of sudan. Previous concepts of the mode of action of coarse feeds in preventing bloat by increasing rumen motility appears to need modification.

Mineral Studies

The Oklahoma station has reported that soft phosphate is not a satisfactory phosphorus (P) supplement while dicalcium phosphate, steamed bonemeal, Curaco Island phosphate, monosodium phosphate and defluorinated rock phosphate are satisfactory. Fattening rations with 0.18% P supplied sufficient P. Diethylstilbestrol did not affect the P requirements.

The addition of vanadium to rumen fluid increased fermentation in Colorado work. The increase ranged from 5 to 100%.

The magnesium (Mg) requirements of sheep have been investigated in Illinois. Previous estimates that 0.06 - 0.08% Mg in the air dry ration is sufficient to prevent Mg deficiency symptoms were verified.

In purified rations Oklahoma workers found that 30% cellulose and 6.5% minerals promoted the most efficient sheep gains. The sulfur requirements were about 0.2% of the ration. This is lower

than other workers have reported.

Missouri work indicates that potassium may be deficient in many high concentrate rations and that ewe rations containing 0.13 to 0.23% calcium are adequate for gestation but not for normal lambing and lactation.

Feed Additives and Implants

The Missouri station has indicated that certain homologs of stilbestrol improve the nitrogen balance even though they have little estrogenic effect.

California workers have reported that the injection of 100 or 300 mg of cortisone three times per week stimulated gain and fat deposition in lambs. However, in one trial with implanted pellets of cortisone there was no significant effect.

General Nutrition

Feed restriction and the subsequent recovery of growing lambs appeared, in California work, to produce less lean body mass than continuous growth. The same workers indicate that maintenance requirements are the same per unit of metabolic body size at all levels of feeding.

Preliminary results from Montana show no appreciable advantage to adding phosphorus and trace minerals to supplemental feed for ewes wintered on Montana range.

The Cornell station has studies in progress testing the effect upon lamb performance of various levels of TDN fed ewes in gestation and lactation as well as various creep combinations for lamb feeding.

In comparisons of 35% versus 56% concentrates; 10, 12, 14 and 16% crude protein; and meal versus pelleted rations for feeder lambs, Missouri work indicated faster gains with pellets, with 56% concentrates and increasing protein levels to 14%. Lambs fed corn silage supplemented with various protein levels did not make satisfactory gains, however the gains were improved at the higher protein levels.

The essentials of a ruminant diet are under study in North Carolina using purified diets. As with natural rations, it appears that B-vitamins are not required in the diet. Alfalfa contains some beneficial factor not present in the basal purified diet. Sheep fed the purified diet have softer depot fat than those fed normal roughage diets.

In the regional project W-34, Range Livestock Nutrition, the Utah station has compared the diets of cattle and sheep on the same range. Sheep diets were higher in forbs and browse and were higher in protein, phosphorus, and some carbohydrate factions than cattle diets. Also at Utah studies of rumen content of volatile fatty acids (VFA) showed an increase on the addition of wheat gluten to the rumen. Added phosphorus decreased the VFA in the rumen.

Also in W-34 the Washington station has work which started in 1961 determining the energy and protein requirements of replacement ewes on the range.

Management

In an Arizona study the apparent conception percentage of grade Rambouillet ewes was increased from 45% in 1960 to 87.5% in 1961 due to the elimination of one ram of low fertility and the adaptation of the other rams to Yuma climate. Low sperm concentration and poor conception early in the season has made it desirable to begin breeding no earlier than October 15. Significant effects upon summer lamb growth resulted from initial age of lamb, the management system used and the sire.

Arkansas workers reported that lambs weaned at 70 lbs. and fattened in drylot gained faster than those that remained on pasture with their dams. Early-weaned lambs gained more rapidly when fed a bulky ration than a high-energy ration. Ewes bred to lamb in November produced more lambs than those bred to lamb in December. Shearing 48 days prior to the start of the breeding season resulted in much better first service conception than shearing 2 days before.

At Georgia the nutritional value and supplementation necessary with fescue, ryegrass and orchardgrass for production of fat spring lambs is being investigated. There has been no significant difference in total gains or slaughter grade between grasses. Creep feeding increased the gains with fescue and ryegrass, but not with orchard-grass. On winter temporary grazing creep feeding corn was just as good as using a 16% protein mixed ration.

High roughage rations were unpalatable in Missouri work. Pelleting doubled the acceptability. Lambs fed a palatable creep mixture made faster gains and were fatter than those fed shelled corn in creeps. As in the above mentioned Arkansas work, lambs weaned and fattened in drylot made faster gains than those suckling dams on pasture.

In Illinois work, legume pastures were superior to nitrated orchardgrass pastures in producing lamb gains. Creep feeding increased gains on nitrated orchardgrass but made little difference on legume pastures. Lambs grew well on rations containing 12.7% to 20.7% crude protein but the rate of gain and feed efficiency increased with the increase in protein. Added lysine did not improve gains, added methionine increased gains only slightly, but together gains were increased markedly. Pelleting increased comsumption and gains but the meal ration required less feed per pound of gain.

In Virginia studies early weaned lambs fed a 65% roughage pelleted ration or a 35% roughage pelleted ration in drylot were compared to control lambs grazed with their mothers. The average daily gains were .65, .72 and .55 pounds and carcass grades were top choice, low prime, and choice respectively.

In two years of summer feeding, Florida workers found comparable gains in sheared and unsheared lambs in one year and significantly increased gains due to shearing the second year.

At North Carolina ewes bred in May and confined in a barn throughout gestation exhibited a higher conception rate, higher lambing percentage and dropped heavier lambs than ewes bred similarly but run on pasture. In other work lambs born in February and March then weaned at 10 weeks grew faster than those left with the ewe. However, early weaned lambs born in December grew more slowly than similar unweaned lambs.

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D. PRODUCTION INFLUENCES ON ANIMAL PRODUCTS

PROBLEM

Efficient production of meat and wool is the ultimate objective of research in breeding, feeding, and physiology. Quality of the product is also a concern of research in these areas. It is not always practical, however, to design research in breeding, nutrition, and physiology to include the quality of the product. Consequently, specific projects are developed to determine the effect of various production practices on the characteristics of animal products. Effective measures of evaluating quality and quantity differences are a very important part of this effort.

PROGRAM OF THE STATE EXPERIMENT STATIONS

A limited amount of research is concerned directly with the influence of nutrition and management on quality of lamb produced, and a concerted effort is being made in the Western region under W-61, Development of Selection Criteria for the Genetic Improvement of Carcass Merit of Sheep, which is cooperative among the States of the Western region and USDA, to define and measure carcass quality and to determine the effectiveness of selection for muscular development. Several stations are studying the pattern of growth in different breeds and crosses as affected by feed, sex and type of birth. Other stations are investigating characteristics in the live animal which may be indicative of carcass merit.

Research primarily classified in this area totals 3.1 professional man-years. Considerable additional effort and the results are included in the sections on Breeding, Nutrition and Management, and Physiology.

RELATED PROGRAMS OF THE USDA

The USDA scientific effort devoted to research in this area totals 3.0 professional man-years. Of this number, 1.3 are devoted to lamb, mutton and chevon; and 1.7 man-years to wool, fur, and fiber.

PROGRESS OF STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

Regional Project W-61

Nine States in the Western region and USDA are pooling data obtained from lamb carcass studies in an attempt to more clearly define and measure carcass merit. Twenty variables will be analyzed, which include a number of live scores and measurements, as well as carcass and wholesale cut measurements. Data have been obtained from

both whiteface and blackface breeds and various breed crosses. Four years' data on approximately 2,000 lambs will be included in the study which will be reported in a regional publication.

In addition to the data collected for pooled analysis, individual stations have preliminary results on this cooperative study.

Results at the California station indicate that a biopsy sampling procedure can be applied to live animals without fear of subsequent disability, and that such samples will have predictive value for carcass characteristics of the same live animal. The present trial indicates that such samples may also furnish information on tenderness and chemical characteristics. Other characteristics, such as muscle fiber or bundle size and color of lean or fat, can also be obtained. This procedure can be applied to live animals for selection for improved carcass quality.

The Utah station has preliminary results from a study designed to determine growth patterns beginning at birth and continuing through a post-weaning feeding period during which different levels of feed were imposed. Preliminary analysis has been completed with that phase of the study dealing with organoleptic and machine tenderness tests. Taste differences did not exist between treatment groups as measured by the taste panel. For some unexplained reason, one group of 10 unweaned lambs averaging 92 days of age, were significantly less tender than those in other treatment groups as measured by the Warner-Bratzler-shear. This difference in tenderness was also observed by members of the taste panel.

At the Oregon station palatability scores on the longissinusdorsi muscle from weaning lamb carcasses indicates no major or consistent difference between different sires within a breed or between breeds. Also at weanling ages ram lambs have not scored significantly below wether lambs.

Results at the Washington station indicate that within groups of lambs which are relatively homogeneous with respect to sex, breed, environment, and age or weight, there appears to be a close and consistent positive relationship between loin eye area and total lean. There is an equally close and positive relationship between total lean and live weight where age is kept constant. The effect of age on muscle development within a range of normal market weights is negligible compared to the effect of weight. Similar results were obtained at the Wyoming station.

Results at the Idaho station from a preliminary analysis on a within year breed and sex basis, discloses that lean carcass mass can be reasonably predicted for the carcasses of lambs using the weights of certain excised muscles and bones.

Preliminary results from a study at the Nevada station comparing breeds and crosses indicate that subjective scores for the size of leg and loin were more useful than a measurement made by probing. At the same station it was noted wethers required more shear force in the rib and leg than ewe lambs.

Results from the New Mexico station indicate a significant relationship between specific gravity and carcass fat. It was found that the relationship is highest between specific gravity obtained from weight in water rather than displacement of water. More consistent correlations were found using data from hot carcasses than from cold carcasses.

The Colorado station completed the study of the variation in the composition of lamb fat from eight different parts of the carcass. A great deal of variation was found to exist between areas, but the composition of fat in each area is high enough correlated with the other areas for sampling from any given area to be reliable.

Fat samples from 165 ram lambs from the U. S. Sheep Experiment Station were analyzed for iodine number, melting point and fatty acid percentages. Fatty acid analysis revealed some interesting differences in the amounts of the various fatty acids present. However, none of the fatty acid percentages were influenced significantly by sires, which was also true for melting point. Iodine numbers, however, were found to be significantly influenced by sires.

Other Research

Lamb carcass studies at other State stations include the following: The Kansas station is studying the relation of feathering and overflow fat of lamb carcasses to the grade of the lamb, degree of marbling, and market value of the lamb. In 1961 the final grade of the carcass showed a high degree of correlation with yield of caul fat, rib-eye color, feathering, fat-streaking, marbling, thickness of fat, overflow of fat, and press fluid, flavor both intensity and desirability, juiciness, tenderness, and number of chews. The 1961 data, however, does not duplicate the previous years' study showing a relationship between grade and palatability.

The Kentucky station conducted carcass evaluation of lambs from selected crosses. Fifty-nine twin lambs grading choice or prime sired by three feed-lot tested Southdown rams mated with similar Western-type ewes, were evaluated for carcass characteristics when they reached approximately 85 pounds. Wether lambs were leaner and had a higher bone percent than ewe lambs. Slower gaining rams sired fatter lambs and faster-gain rams sired meatier lambs.

At the Missouri station evaluation of lamb carcasses by sire groups showed differences attributed to sire influence.

At the Georgia station in limited hand feeding compared with free choice creep feeding, carcasses from the creep free choice lots graded 1/3 to 2/3 of a grade higher than those in the limited hand fed lot. Pelleted creep, fed free choice, produced carcasses that graded higher than those from lambs fed mash creep, free choice.

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E. INFECTIOUS AND NONINFECTIOUS DISEASES

PROBLEM

Disease in sheep causes major economic loss to the industry. Some diseases tend to affect particular segments of the industry while others inflict their damage in a more general scope. For example ovine vibriosis is one of the two major infectious diseases resulting in abortion in sheep in the United States. It has been estimated that losses from this disease in the past, have exceeded 100,000 lambs a year. The infection occurs in all of the major sheep raising areas of the United States. Urolithiasis (urinary calculi) is an example of a problem which is somewhat more restrictive in its occurrence. It is the cause of substantial economic loss primarily in feedlot and range sheep. Research on these and other disease problems of sheep is directed toward development of information which can be used to positively identify, simply diagnose, and prevent or control the disease. This involves studying the characteristics of causative agents, learning the means or ways of transmission of infections between individual animals and from one flock to another and investigating the practicability of preventive vaccines. For problems like urolithiasis, efforts are being directed to determining the physiological circumstances which lead to the formation of these precipitates. Understanding basic disease mechanisms and manifestations is fundamental to disease control and therapy.

Of the 212 professional man-years devoted to research on animal disease and parasites, 11.3 are given to infectious and non-infectious diseases of sheep and goats.

PROGRAM OF THE STATE EXPERIMENT STATIONS

Vibriosis
(5.6 professional man-years)

Nearly all of the research on ovine vibriosis is coordinated through the Western Regional Project W-27, Vibriosis in Sheep. This is a cooperative investigation between six western States and the USDA with active support from the National Wool Growers Association. This research seeks to develop methods for diagnosis, prevention, and control of the disease, also, information on the reservoirs of infection and means of spread is sought. Preventive vaccines are being tested. Detailed cultural and serological studies are in progress on strains of the vibrio with the objective of finding improved methods for differentiating pathogenic from nonpathogenic types. The possible interrelationships between vibriosis and ovine virus abortion is being studied.

Scrapie
(0.2 professional man-year)

Limited studies are aimed at improving methods for diagnosing outbreaks of scrapie. Improved methods are needed for distinguishing this disease from other diseases which produce a similar clinical picture.

Bluetongue
(0.5 professional man-year)

This research is cooperative with the USDA and is directed toward the development of a reliable and practical laboratory test that can be used to identify outbreaks of bluetongue in sheep and animal carriers of the disease. A critical evaluation of procedures developed thus far is being made to determine their acceptability. Vaccines for the prevention of the disease are being evaluated. Vectors, in addition to those known, are being sought in order to improve control procedures.

Other Diseases - Pneumonia, Mastitis, Caseous Lymphadenitis, Listeriosis, etc.
(5.0 professional man-years)

The causes of pneumonia in lambs is being determined and methods for prevention are being developed. The possible role of other diseases in contributing to pneumonia is being evaluated. Management procedures for prevention are being developed. The cause and prevention of encephalomalacia is receiving attention. The significance of eperythrozoonosis of sheep is being determined. Research is under way to identify the cause of balanoposthitis in rams and to develop procedures suitable for control. Improved methods for treating foot rot of sheep are under evaluation. The causes of mastitis in ewes are being studied. Factors which contribute to outbreaks of listeriosis in sheep are being elucidated. Also, basic studies are in progress on listeriosis to determine the physiological and cellular alterations occurring in infected animals in order to understand how the disease develops. The causes of urinary calculi in sheep and methods for preventing the condition are sought. Changes occurring in the physiological and biochemical elements of affected animals are being studied in detail to reveal the underlying causes leading to the disease.

RELATED PROGRAMS OF THE USDA

The USDA scientific effort devoted to research in this area totals 6.6 professional man-years and is divided as follows: bluetongue, 2.0; contagious ecthyma, 2.0; foot rot, 2.0; scrapie, 0.2; vibriosis, 0.3; and viral ulcerative dermatosis, 0.1.

PROGRESS OF STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

Vibriosis and Virus Abortion

Vibrio fetus bacterin prepared at the Kentucky station reduced the duration of a vibrio bacteremia from 3.6 and 3.1 days to 1.6 and 1.5 days in laboratory infected groups of animals.

In Idaho vibriosis was diagnosed in 4 flocks, while virus abortion was found in 10 flocks. Six thousand yearling ewes are being used in vibriosis immunity study in which one half were vaccinated and one half were used as the control group.

Cross immunization studies are in progress at the Colorado station to determine the protection afforded sheep vaccinated with V. fetus (serotype I) killed vaccine when challenged with serotype V live culture and vice versa. This will determine the immunogenicity of a single strain or the necessity of combined serologic different strains to immunize against vibrionic abortion.

Work was started at Montana on the pathogenicity of vibrios isolated from ovine bile. Experiments indicate that bile carriers are a potential hazard to pregnant ewes. This probably explains the origin of many new outbreaks of vibriosis.

In Montana evidence was encountered which suggested that the experimental flock of sheep, thought previously to have been free of ovine virus abortion, may have become infected. The presence of infection in a flock showing little or no clinical evidence of disease suggests that virus abortion may be widespread causing light losses at lambing which are regarded as normal.

Indications in one set of experiments at Utah were that the vaccination of replacement ewes would eliminate the V. fetus carrier state in a herd of breeding ewes.

V. fetus represents a group of organisms with varied amino acid requirement. Virginia workers have shown that cultures can be divided into at least 4 groupings on the basis of their amino acid requirements. Amino acids were shown to be deaminated by growing and resting cells of the organism.

At Wyoming the antigens of V. fetus were studied by electrophoretic separation. It was found that the buffer used was very important with reference to the rate at which antigen separation occurred.

According to the Idaho workers two and possibly three types of V. fetus may be differentiated by physiological properties. Bovine kidney tissue cultures appear to be an ideal medium for rapid growth

and stabilization of V. fetus cultures.

Urinary calculi

Preliminary studies at Idaho suggest that urinary calculi may be associated with high protein intake.

At California increase in the insoluble sediment per day was observed in the urine of sheep receiving a grain diet as compared with sheep on hay.

Based on clinical urolithiasis in Wyoming, there was no difference between K_2HPO_4 and Na_2HPO_4 in the production of stones. Chelating agents -- calcium disodium versarate (calcium disodium ethylenediamine tetracetate) and versene (sodium tetraethylenediamine tetracetate) -- did not reduce the incidence of "waterbelly" when fed at the rate of 2 Gm. per animal every 7 days. Similar results were obtained by injecting calcium disodium versarate intramuscularly.

Pneumonia

A psittacosis-lymphogranuloma venereum virus was isolated from the feces of normal sheep in California which upon intratracheal inoculation produced lung lesions indistinguishable from those produced by the sheep pneumonitis virus.

Bluetongue

Studies in California have established the influence of the type of cells, the composition and pH of the medium, and the temperature of incubation on the propagation of the bluetongue virus in tissue culture. From these data, the optimum conditions for cultivating the virus have been ascertained.

A strain of bluetongue virus previously adapted to the suckling mouse brain was further studied at Washington. It was shown that the relationship of mouse age to virus susceptibility was influenced by the virus passage level used. Virus of the 53rd passage produced mortality in 5-month-old mice. A study of virus multiplication in 1-to 3-month-old mice revealed an earlier reduction of infectivity in brains of surviving mice than in mice that succumbed to the infection (Coop. USDA).

Ovine Mastitis

A living, non-pathogenic variant of Pasturella hemolytica grown on solid medium gave no apparent protection when used as a vaccine against ovine mastitis (Mont.).

Ulcerative dermatosis

Material was obtained in Wyoming from field outbreaks of ulcerative dermatosis. Some animals showed vulvitis and others showed lesions on the face and lips. Material from the latter location was filtered bacteria-free and inoculated into sheep showing vulvitis and vice versa. Sheep showing vulvitis were susceptible to inoculation with material from the sheep showing facial lesions and the latter were susceptible to material from ewes showing vulvitis. Sheep infected with ulcerative dermatosis virus were susceptible to contagious ecthyma virus.

PUBLICATIONS REPORTING RESULTS OF STATE EXPERIMENT STATIONS AND COOPERATIVE RESEARCH

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F. PARASITES AND PARASITIC DISEASES

PROBLEM

Disorders caused by parasites are ubiquitous, generally insidious and often overlooked entirely. Diagnosis of parasitism is often difficult and successful treatments for many parasitisms are not available. Management practices to avoid spread of parasitisms and to control them are often ineffectual. The objective is to develop, through a planned, balanced program of basic and applied research, knowledge for preventing, controlling or eliminating parasitic diseases so as to provide for healthy animals which will efficiently convert plant materials into high quality animal products.

Of the 212 professional man-years devoted to research on animal disease and parasites, 5.6 deal specifically with parasites and parasitic diseases of sheep and goats.

PROGRAM OF THE STATE EXPERIMENT STATIONS

Lungworms
(0.4 professional man-year)

Studies are aimed at locating areas of parasitism with the lungworm and developing information on the habits of the parasite which will be useful in its control.

Bionomics of Coccidial Parasites
(0.4 professional man-year)

Research is directed primarily toward means for controlling this protozoan parasite.

Gastrointestinal Nematodes
(3.3 professional man-years)

Cooperative studies through regional research project W-35, Nematode Parasites of Ruminants, seek to clarify some of the major problems caused by this group of parasites. Management procedures are being developed based on critical observation of parasite incidence under different systems of flock management. Genetic resistance is being evaluated with the possibility that some breeds, or lines within breeds, may be more resistant to certain parasites. Improved methods are being developed for diagnosing infections with specific parasite species.

Biology of the Liver Fluke
(1.5 professional man-years)

Parasitologists are seeking to identify snails which serve as intermediate hosts of liver flukes and are determining factors concerning the ecology of these snails which may provide a means for breaking the life cycle of the fluke. Enzootic areas of fluke infestation are being located and methods of elimination evaluated. Studies are aimed at measuring precisely the damage caused by flukes and how this damage is produced in order that scientifically sound countermeasures can be evolved. Prevention through immunization is understudy. Existing control measures are being applied to determine their effectiveness under conditions found within the several States.

RELATED PROGRAMS OF THE USDA

The USDA scientific effort devoted to research in this area totals 8.3 professional man-years and is divided as follows: lungworms, 1.0; bionomics of coccidial parasites, 2.0; effects of helminth infections on serum protein, 0.5; gastrointestinal nematodes, 2.1; helminth and protozoan parasitism in the south, 1.5; biology, pathogenesis, and control of helminth parasites of sheep in the southwest, 1.0; biology of the liver fluke, 0.1; and effect of intestinal roundworms on metabolism, 0.1.

PROGRESS OF STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

Lungworms

In Wyoming a first-stage larva of Dictycaulus sp. was recovered from earth worms gathered in a pasture where there were sheep infected with lungworms. The earthworms were kept for 21 days under conditions in which first-stage larvae would have developed to third-stage in 3 to 4 days. The implication is that the earthworm was acting as a protective host.

Studies with lambs (and calves) in Virginia infected with Dictyocaulus species showed that eosinophil count was the best indication of infection. Electrophoretic pattern showed an increase in globulins.

Fringed tapeworms

Attempts are being made in South Dakota to determine how lambs acquire fringed tapeworms. Efforts to incriminate ants as intermediate hosts have been abandoned and psocids (plant mites) are being studied as possible intermediate hosts. Psocids have been kept alive in the laboratory for more than 6 months.

Gastrointestinal nematodes

An examination of the degree of parasitism in 118 male and female lambs of two breeds in Nevada indicated significant differences in the degree of susceptibility. These results indicated that Rambouillet lambs were more resistant to parasitism than Hampshire lambs.

Serum protein fractionation by paper electrophoresis by Nevada researchers has indicated a significant increase in the gamma globulin and a decrease in the albumen in parasitized ewes.

Wool samples taken at slaughter from eight lambs, which were raised parasite free until they weighed 60 pounds and then infected with Trichostrongylus sp., were found to have decreased sulfur content but the tensile strength was unaffected (North Dakota).

Tests are in progress in Montana to determine the relative efficacy of purified, fine-particle phenothiazine and thiabendazole benzimidazole against Chabertia ovina of sheep.

The feces of 210 lambs of 5 different breeds were examined quantitatively by the Idaho workers for trichostrongylid eggs per gram in an effort to show that there is a statistically significant difference in the extent of parasitism of different breeds, when exposed to the prevailing pasture infection source. The results of the study indicate the Suffolk is most susceptible and the Targhee most resistant to ostertagiasis with the Panama and Panama-Targhee crossbreds paralleling the Targhee in resistance.

Through the management practices of only permitting the ewes to graze on pasture and keeping the lambs in drylot, it was shown by Illinois research that parasitism of the lambs with Strongylus could be almost completely prevented.

At Wyoming antibodies were detected by means of the hemagglutination test in sera from ruminants with mixed roundworm infections. Pre-infection sera were tested and found to have low or negative titers. A group is now being studied to evaluate the status of immunity resulting from infection with Cooperia oncophora followed by treatment.

Trichostrongylosis was seen in young sheep for the first time in Wyoming and the num ber of worms ranged from 10 to 70 thousand. Nearly all were Trichostrongylus colubriformis.

Iron metabolism studies in California in parasitized ruminants revealed a hypoplastic anemia which may be complicated by marrow hemolysis. In an allied study in mice infected with Nematospiroides dubius, there was an increase in cytochrome-c in heart muscle and a shift of iron from hemosiderin to ferritin.

At Alabama the amount of blood loss as a result of Haemonchus contortus infection was measured in sheep by using blood tagged with radioactive chromium. It was possible to measure the blood loss caused by each parasite. Studies were extended to determine the quantity of iron that was re-utilized by the sheep after it has passed through the parasites. It was found that most of the iron passed through the digestive system without being reutilized.

Small field plots were utilized to screen nematocides. Nemagon spray was effective at 31.4 lbs./a. (South Carolina).

One flock of sheep was given 13 treatments of either Ruelene or phenothiazine at 28 day intervals. The general appearance and thriftiness of the sheep improved during the treatment period. (South Carolina).

In Virginia 68 percent of the sheep (and 40 percent of the cattle) were infected with the esophagus worm, Gongylonema pulchrum. A high percentage of the deer also were infected with this parasite.

In field experience, thiabendazole is a more effective drug and has a broader range than phenothiazine (Virginia).

Flukes

In Nevada monthly and bimonthly observations are being used to survey trematode (fluke) incidence among lambs and ewes. Infection has been found to be most severe in the late fall and early winter. Most of the fascioliasis has been observed in older ewes.

Workers at Nevada also showed that an intramuscular injection of 2 ml. of carbontetrachloride mixed with 2 ml. of a light weight mineral oil was highly useful in killing adult flukes but not immature forms. Toxicity studies indicate that carbontetrachloride is relatively nontoxic when administered in this manner. Eight times this dose injected daily for 5 days was not lethal.

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G. SHEEP AND WOOL INSECTS

PROBLEM

Sheep are attacked by a variety of insects and ticks that are responsible for losses of many millions of dollars annually in reduced weight gains, decreased production and quality of wool, and in deaths of animals from gross attacks and insect-borne diseases. Sheep keds are a particularly serious pest in the northern States and screw-worms in the southwestern States. Fleeceworms, lice, and ticks are important pests wherever sheep are raised. Safer, more effective, non-residue-forming insecticides are needed to combat these pests. There is a special need to develop systemic insecticides which when given at low levels in feed, salt, or water would effectively control pests of sheep and thereby save growers the expense of rounding up and treating flocks several times a year. New approaches to control, including attractants, chemosterilants, and radiation, should be explored and developed for controlling certain pests, as was done for the screw-worm in the Southeast. The possibilities of controlling insect pests of sheep with insect pathogens, parasites, and predators also need to be investigated. Additional basic studies on the biology of the insects involved are essential for the development of biological and sanitation measures for their control. Research is urgently needed to determine which insects other than sand flies transmit bluetongue and the role of insects and ticks in the spread of other diseases of sheep.

Animal fibers in raw or manufactured form are subject to damage by fabric insects, which are estimated to cause annual losses of about $350 million. Effective and safe control methods are needed to be used in homes, retail stores, warehouses, woolen mills, and manufacturing plants to control the fabric insects that infest the premises. Improved fabric treatments and methods of application are needed to prevent the extensive feeding damage by insects. Basic research on the physiology and chemistry of wool digestion by insects is needed to provide information leading toward the development of better preventive treatments.

PROGRAM OF THE STATE EXPERIMENT STATIONS

The occurrence, behavior and control of sheep ked, ticks, sheep bot fly, and other sheep pests are under study. A basic scientific study of the occurrence of pesticide residues in sheep tissues and the effect of these residues on growth and reproduction is being made.

The research on sheep and wool insects at the State experiment stations in 1961 totaled 0.9 scientific man-years of effort. Of this total, 0.3 man-years were devoted to basic biology, physiology and nutrition, 0.4 man-years to control and 0.2 man-years to insecticide residues.

RELATED PROGRAMS OF THE USDA

The USDA scientific effort in this area totals 4.7 professional man-years. Of this number 1.9 man-years are devoted to basic biology, physiology and nutrition, 1.4 to insecticidal and sanitation control, 0.4 to insecticide residue determinations, 0.4 to insect sterility, attractants and other new approaches to control, and 0.6 to insect vectors of diseases.

PROGRESS OF STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

One (The Kentucky) station reported lots of 5 lambs each were treated with 5 organic phosphate insecticides for control of grubs of sheep bot fly (nose bot). Virtually 100% control was obtained with 4 of the materials and 63% control with the fifth compound. The insecticides were applied by intramuscular injection and as a drench. In 3 animals in which virtually 100% control was obtained, a single 3rd instar grub was found. Most of the larvae found in the controls and the treatment giving 63% control were first instar larvae. The control animals averaged 19.1 grubs per head.

One (The Utah) station completed field work in the study of long-term oral exposure of sheep to dieldrin and the ewes were sacrificed. Prior to this, final estimates of daily dieldrin retention were made during the fourth gestation and lactation of these ewes. A series of blood chemistry analyses were made to help evaluate the final physiological state of the animals. After slaughter an autopsy examination was made on each sheep and tissues were sampled for histological examination for evidences of pathology. The animals' bodies were subjected to a complete analysis for water, ash, protein, fat, and dieldrin. This will provide an accurate evaluation of the composition (or condition) of each animal and the total amount of dieldrin retained by each animal at the end of the experiment. The analytical work was nearly completed in 1961 except for a large portion of the necessary dieldrin analyses. The effect of dieldrin on reproduction of ewes which involved survival of the newborn lambs was studied further. The observations tended to confirm the relative vulnerability of lambs born to ewes receiving the highest levels of dieldrin.

PUBLICATIONS REPORTING RESULTS OF STATE EXPERIMENT STATIONS AND COOPERATIVE RESEARCH

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II. MARKETING AND ECONOMICS RESEARCH

H. MARKET QUALITY

Research conducted at State stations on the market quality of meat often encompasses work on lamb, pork and beef. It includes work aimed at developing objective measures for determining the quality of meat; including changes in chemical and physical properties of meat which may occur in handling, storage and distribution of meat. Other factors under study include the influence of ante- and post-mortem treatments as well as changes in such quality attributes as color, tenderness and flavor of meat. Packaging and storage research involves search for more effective means for control or prevention of quality losses incurred through microbial spoilage, moisture loss and color deterioration. The research is generally organized along functional rather than commodity lines. Current progress reported relates to meat quality in general.

PROBLEM

Meat is a perishable commodity and varies greatly in quality characteristics. An increase of only a few days in shelf-life would greatly improve marketing possibilities. Better methods for precisely determining, defining and standardizing meat quality are needed. Also needed are better ways to preserve and package meat while it is moving in the channels of trade. Additional research is needed on: the effects of heredity, nutrition and management factors on meat quality; development of objective, easily applied methods for defining quality; the physical and chemical composition of meat; and, the changes taking place during the onset and resolution of rigor mortis.

PROGRAM OF THE STATE EXPERIMENT STATIONS

Objective Measurement and Evaluation of Quality

(6.7 professional man-years)

Techniques for the objective measurement of meat quality are being investigated. The research is being conducted on beef, lamb and pork. These studies include development of physical methods and their application in estimating meat quality at the processed, carcass and/or live animal level. Data are obtained on the physical and chemical properties and changes in fat and protein; histological structure; changes in color; and, collagen content. The influences of genetic and preslaughter treatments on quality and quality measurements are also determined.

Quality Maintenance in Handling, Packaging, and Storage

(1.4 professional man-years)

Curing, storage, handling, and packaging research is concerned with meat quality. Packaging materials are governed by the type of product involved. These materials aid in maintaining product color, moisture content and prevention of off-odor pick-up and microbial spoilage.

RELATED PROGRAMS OF THE USDA

The Federal scientific effort devoted to research in this area totals 3.6 professional man-years, of which 2.4 man-years is by research contract. The total effort is devoted to objective measurement and evaluation of quality. During the report period, work on criteria for identifying meat-type hogs and feeder pigs was completed. Studies on gamma-ray measurements of meat cuts were also completed.

PROGRESS OF STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

Objective Measurement and Evaluation of Quality

The need for greater precision than usually afforded by live animal evaluations has led to rapid development of methods for evaluating meat animals. State station researchers use cattle, sheep or swine of known genetic background and management history in attempts to improve the methods and applications of quality measurements.

In work at the Missouri station, an ultrasonic instrument was used to estimate the area of the rib eye muscle and fat thickness of 202 beef cattle. Correlations were made between live animal estimates and carcass measurements. Georgia researchers also used ultrasonic and other methods of estimating muscling in beef cattle. Slaughter steers of various weights and grades were used in a study in which separation of bone and chemical analysis of the remainder of the carcass for fat and protein were used. Ultrasonic readings of the lumbar longissimus dorsi, biceps femaris and muscle:bone ratio were obtained. Correlation coefficients between ultrasonic estimates and actual measurements were obtained. An ultrasonic technique was developed and used by Cornell workers to produce cross-sectional outlines of the rib eye and associated fat at the 13th rib of cattle and hogs. Comparison of repeated ultrasonic measurements indicated a significant repeatability. Correlation coefficients for ultrasonic and carcass fat thickness were made. Relationships were higher for hogs than for cattle.

In work directed toward finding indices for lean carcass composition, Kentucky station personnel have studied carcass characteristics

as predictors of carcass composition. Search for objective measures or indices of pork carcass meatiness has also been the aim of work in progress at the Florida station.

In a Kansas study, 32 crossbred lambs were used to study the effect of preslaughter treatment and stress on some carcass characteristics. The effect of preslaughter stress was significant on pH and color. Myoglobin concentration, expressible moisture in the longissimus dorsi muscle and firmness of fat were not significantly affected by preslaughter treatment.

Basic physical and chemical properties and structure of muscles influence ultimate meat quality. Practical studies of meat quality are often hindered by lack of basic information on the structure and constituents of muscles and their changes during the onset and resolution of rigor mortis. At Wisconsin, an apparatus has been developed to study the extensibility and elasticity characteristics of muscle fiber before and during the onset of rigor mortis. Observations on the relation of these changes to the ultimate muscle characteristics are in progress and different time period, temperatures, and gaseous atmospheres are being studied. Other workers at this station have developed a photo-densitrometer and applied it as an objective means of measuring intra-muscular fat levels of beef and pork longissimus dorsi muscle. Results obtained on 37 pork and 77 beef muscle samples ranging from 5 to 46% ether-extractable fat (MFB), gave repeatability correlations of 0.995 and 0.982 respectively. All reported correlation values were significant ($p < .01$).

The effects of added dietary fat on fatty acid composition and characteristics of fattening steers are under investigation at the North Carolina station. Addition of animal fat to the steer rations resulted in a significant increase in percentage of separable rib fat in those animals previously receiving a low-energy ration but not in steers wintered on a high-energy ration. Colorado workers have conducted studies on the composition of ovine fat. Gas chromatography, iodine numbers and melting points were used in determination of fat composition. Fatty acid analysis by gas chromatography revealed interesting differences in the amounts of the various fatty acids present. Statistical analyses of these data showed that breed differences had a non-significant effect on the iodine number, melting point and percent of the various fatty acids.

Quality Maintenance in Handling, Packaging, and Storage

Changes in meat quality begin with slaughter and continue to occur as the meat progresses through the marketing channels. Meat

quality per se has received increasingly more study in recent years.

The chemical changes that take place just after slaughter have a lot to do with just how good the meat will be. Researchers at the University of Wisconsin have shown that one of the most important post-mortem changes is the breakdown of glycogen--animal starch--into mild acids. These acids are undesirable because they bring about the pale, soft, watery condition that consumers complain about. Recent tests revealed that the rate at which glycogen is broken down is more important than the amount of carbohydrate present initially. If the acids are produced just before or just after death, while the carcass is still at body temperature, they are more harmful than if they are produced later on. In tests with three breeds, the workers found some important differences both in amount of glycogen present and the rate at which it is broken down. The cause of the differences in glycogen breakdown isn't clear and will be subjected to further study.

Researchers at the New Jersey station have investigated factors which affect the color of packaged retail beef cuts in storage. A method called Pair Testing was developed to reduce to a minimum the variability in samples used for control and treatment. The effect of oxygen at 760 mm Hg. for various times from 0 to 5 days at 32° F. was found to be cumulative, that is, those samples receiving the longest oxygen treatment retained color best. Extreme differences in color retention of beef from different muscles was observed. This work is being extended to include determination of chemical differences between meat of good color retention and meat of poor color retention.

Discoloration of red meats due to metmyoglobin formation continues to be a problem in self-service retailing. Methods for determining discoloration rates in fresh red meat are being studied by workers at the Iowa station. Results have shown that the temperature of storage affects not only the rate of discoloration but also the form of the rate curve. This study is continuing.

A study of the microbial flora of several types of packaged meats available in self-service counters has been in progress during the last few years at the Kansas station. Wide variation in numbers of bacteria on different samples of meat were found. Results indicate a variation in sanitary procedures and in keeping quality.

In other work, related to quality, Missouri personnel reported hydroxyproline content was a better measure of the tenderness of less tender steaks than of tender steaks; and Georgia workers compared three methods of detecting spoilage in meat in a search for rapid methods for determining the shelf-life of meat. Research in progress

at Michigan seeks to fractionate the component(s) responsible for the sex odor/flavor in pork. Results to date indicate sex odor to be water-insoluble, ether-soluble, and definitely associated with the fatty tissues of boars.

California researchers have in progress a study in which comparisons of yields, eating quality and moisture, and ether extract of three cuts from new crop lambs (5-1/2 months) and old crop lambs (1 year) are being made. Results to date show cuts from the old-crop animals contained more lean and less bone. The lean tissue of the new-crop cuts was higher in moisture content and lower in ether-extractable material. The study of eating quality is continuing. A comprehensive study of the factors in flavor and tenderness of lamb, beef and pork, and techniques of evaluation has recently been summarized by the Washington station.

PUBLICATIONS REPORTING RESULTS OF STATE EXPERIMENT STATIONS AND COOPERATIVE RESEARCH

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I. ECONOMICS OF PRODUCTION AND MARKETING

PROBLEM

There is need for more effective methods to minimize shrinkage of live animals as well as meats as they move through the marketing functions and channels of trade. In the economics of production, more emphasis is needed in the improvement of quality of lambs and wool produced for market, lowering costs and increasing rates of production, and rates of returns. Also needed are improved management practices and enterprise organization to insure greater efficiency in operation.

Wool varies widely in physical characteristics that affect its quality and use. Research is needed to determine the relationships of primary physical characteristics to processing performance and market values of wool. Improvement in marketing efficiency requires the development of a method of sampling, measuring and describing producer-owned wools so that they can be marketed on a merit basis.

PROGRAM OF THE STATE EXPERIMENT STATIONS

In addition to the research reported below that is being conducted by the State agricultural experiment stations on the economics of sheep and wool production and marketing, other production economic research involving these commodities is included in studies of a broader nature covering additional enterprises. These studies involve the operations of the entire farm unit consisting of a number of enterprises of which sheep is only one of several. Problems in management, structure and overall adjustments, land economics, agricultural finance and taxation, and general economic analysis that apply to the entire farm are not segregated on a commodity or enterprise basis.

Research in the economics of marketing of sheep and wool by the State experiment stations amounted to 1.3 man-years during 1962. The work underway pertains to the determination of marketing costs, margins and efficiency in the marketing of lambs and wool, market structure and practices of wool, economics and product quality and grade of wool, and the economic evaluation of market information services for wool. Under the economics of production the research at State stations emphasized methods of organization and enterprise planning, costs of production, and returns to producers.

Under regional project WM-23, seven western states and USDA are cooperating in research to improve the marketing of western wool. The work involves studies of the physical characteristics of different grades and types of wools in relation to their combing performance and market values, usefulness of objective measurements of grease wool in marketing the product on a merit basis, and analyses of marketing practices and functions and the sources and volumes of wool supplies.

PROGRESS OF STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

Economics of Production

The results of a western regional research project, in which twelve State stations and the USDA cooperated, show that the quality of wool produced in the twelve States varies from fine to common and braid wools with all the variations in between. The quality of wool produced changed much less rapidly than the amount produced. The average annual production for these States from 1955-59 amounted to almost 160,000,000 pounds. Conditions for wool production varied widely between areas, but where conditions were somewhat similar in certain areas, similar types of sheep were run. One station (New Mexico) conducted research on the economics of lambing on crested wheatgrass, and found that after all costs were paid, ewes increased the return to the operator for his labor and management from 19 to 27 percent over that received when ewes were lambed on native range. The station also reports that in studying ranch enterprises, production rates in the northern part of the State are mostly lower than in the southern part, and that labor costs are the largest single item of expense followed by feed costs in sheep production.

In studying costs and returns on farm flock sheep production, another station (Utah) determined that the average total cost of production per breeding ewe was $41.92, the average total receipts amounted to $33.59, resulting in a minus net return. In somewhat related research in determining the cost of producing lambs and wool, another State station (Texas) reported the cost of $13.85 in maintaining an ewe per year, and the cost per pound of lamb was estimated at 16 cents, and the cost of producing a pound of wool was 59.1 cents. Progress is also being made by another State station (Wyoming) in conducting research to determine current costs, returns and investment requirements per head for range-sheep production in important producing areas of the State. One of the southern State stations (Louisiana) in assembling data for planning sheep enterprises in the State, prepared budgets indicating costs and returns for three systems of production - farm flocks, range flocks and winter grazing lambs. The budgets consider the returns for sheep enterprises which are independent of other farm enterprises.

A midwestern station (Ohio) in conducting research on cost and returns of feeding lambs, reports that the costs experienced by commerical lamb feeders in the central part of the State averaged $22.56 per lamb sold in the 1957-58 season. The costs involved were broken down in their various component parts, and the returns per lamb

amounted to $23.00, leaving a net return averaging 44 cents per head sold. In making an economic analysis of the effects of alternative shearing methods on wool quality, another midwestern station (South Dakota) concluded that there is a maximum increase in the quality and value of the wool clip shich can be attained through the adoption of tagging or other practices with a given set of resources and the given quantity of wool which results. Because of the supplementary nature of the farm flock sheep enterprise, the maximum appears to be quite low.

Economics of Marketing

In reporting on results obtained from research on methods of marketing wool, one western station (Montana) indicates that wool pool sales in 1956 and 1957 accounted for about 20 percent of the total sales in the State, and that there seemed to be an advantage for producers with 400 head or less to sell their wool through a pool. It was admitted, however, that the advantage of selling through pools may extend to producers with larger clips. Wool was sold through three types of buyers - manufacturers, cooperatives, and handler-dealers. In 1956 and 1957 manufacturers recorded the highest price paid for wool, while both cooperatives and handler-dealers recorded prices below the State average price.

Another State station (Texas) is engaged in three wool marketing studies directed towards securing information on the effect of incentive programs on sales and prices of wool sold in the State during the 1960 marketing year; to determine the characteristics and feasibility of marketing grease wool on a known quality basis; and to study other wool marketing problems in the State. Some phases of the above research have been completed and the results released in bulletin form, while other aspects of the research continue under satisfactory progress.

One north central station (Ohio) reports on research that has been conducted on cost and returns from sorting fleece wools for market in the producer's warehouse. The report concludes that in general, buyer comments and non-price evaluations indicated that sorting or skirting and putting up wool as was done in the warehouse has the following distinct advantages for processors: (1) eliminates processor costs of untying fleeces, (2) reduces processor labor costs as no additional sorting was needed, (3) eliminates much of the foreign materials and stains in the fleece, (4) improves the uniformity of the lot, and (5) reduces gray and black fiber contamination as leg and face wools were removed.

Another western station (Wyoming) is engaged in research that pertains to (1) the economic marketing of wool, and (2) the processing of grease wools in the west. Under the former, problems are being considered that effect costs and net returns to the grower. Both phases of research are progressing satisfactorily and progress reports have been made but no final conclusions in the form of results have been released.

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III. HUMAN NUTRITION AND CONSUMER-USE RESEARCH

The research is organized for the most part on a functional basis in terms of consumers' problems in selecting, using and caring for food, clothing and household textiles. Details on the current programs are presented as they pertain to (1) lamb and (2) wool fabrics in apparel and house furnishings.

J. LAMB

PROBLEM

Characteristics of livestock products, including lamb, on the retail market are constantly changing with the adoption of new production, processing, and marketing practices. Research on the nutrient content of cooked lamb and on the cooking losses and eating quality of lamb are essential to promote wider use of this meat. Knowledge of the inherent values of different products available and how to conserve and enhance them is basic to proper household preparation and processing. Consumers want flavorful, tender, juicy products with a high yield of edible lean meat. They spend more than a fourth of the food dollar for meat and meat products. Livestock products make important contributions to human nutrition, i.e. high quality protein, iron, and several B vitamins.

PROGRAM OF THE STATE EXPERIMENT STATIONS

Food scientists and nutritionists in Home Economics research in State experiment stations have contributed to knowledge of the nutrient composition of cooked lamb and the cutting and cooking losses of roast lamb. Studies of the nutrient content of different cuts of cooked lamb include analyses of protein, ash, total fat, the vitamins thiamine, riboflavin and niacin, and the amino acid tryptophan. Studies of consumer acceptability of lamb have also been included in several investigations. Food research scientists are using chemical, physical and sensory techniques to investigate the components of flavor of fresh and cooked lamb and mutton, and the effects of method of cookery on these flavors. This program currently totals 0.6 professional man years.

RELATED PROGRAMS OF THE USDA

No USDA program on lamb in this area.

PROGRESS OF STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

Nutritive Values and Cooking Losses of Lamb

In Minnesota Isabel Noble and Lucille Gomez used paired 2½ to 3-lb. loin rack roasts from Choice lamb carcasses. One member of each pair was cooked in an electronic range the other in a conventional oven. Prior to cooking, approximately 100 gm were cut from each end of roasts for analyses of the raw sample.

Comparisons were made of the thiamine, riboflavin, fat, moisture, and weight changes in these roasts cooked in an electronic and in a conventional range. In none of these respects were the roasts cooked electronically significantly different from those cooked conventionally. Average thiamine and riboflavin retentions were 56 and 80 percent, respectively, of the amount present in the raw meat. Weight loss during cooking averaged 25 percent of the raw edible portion. Approximately two-thirds of this loss was due to evaporation, the rest to drippings. The mean content of vitamins, fat and moisture in the raw lamb per 100 grams was 0.138 mg thiamine, 0.170 mg riboflavin, 31 grams fat and 51 grams moisture. In the cooked lamb the mean content per 100 grams was 0.106 mg thiamine, 0.182 mg riboflavin, 38 grams fat and 42 grams moisture.

Cecilia Schuck, Lida Burrill and Dorothy Deethardt in South Dakota determined the cutting and cooking losses in 204 legs of lamb purchased from a wholesale meat company in Sioux Falls over a period of time. The lamb legs were trimmed to remove the outside visible fat, deboned, and tied by experienced members of the meat cutting laboratory. The roasts were cooked in the college cafeterias in ovens set at 325° F., to an internal temperature of 180° F.

Cutting losses ranged from 25.8 to 30.9 percent, and averaged 28.8 percent. Cooking losses ranged from 28.8 to 35.9 percent and averaged 34.8 percent. The yield of cooked meat in terms of percent of meat purchased was 44 to 52 percent, with an average of 46 percent. Drippings accounted for 19.3 to 22.5 percent of the cooking losses.

Sixty-seven samples of roast leg of lamb, representing the lean marbled portion of the meat were analyzed for moisture, protein, fat, ash, tryptophan, and niacin. Calorie values were computed on the basis of the protein and fat analyses, and niacin equivalents were calculated from the niacin and tryptophan assays. The means expressed as grams per 100 grams of meat were: moisture, 55.3; protein, 28.7; fat, 14.2; and ash, 1.1; expressed as mg per 100 gm of meat: tryptophan, 4.2; and niacin, 5.8. The computed values per 100 grams were 251 calories and 5.9 mg niacine equivalents.

Consumer Preference and Quality Discrimination

South Dakota workers attempted to measure the extent to which students at South Dakota State College would eat lamb when it was served in the college cafeterias. In a study of food preferences, responses of freshmen students to a questionnaire indicated that 20 to 30 percent had never tasted lamb, 5 to 10 percent were unwilling to eat it at all, and 10 to 20 percent were unwilling to eat it often.

Two methods of measuring acceptability were used: (1) Plate waste was determined when roast leg of lamb was served as the only meat. This measure was compared with measures of plate waste of beef, pork, and ham when each was served alone. (2) A count was obtained for the number of students choosing lamb when a choice of meat, beef, pork, or ham was offered.

Plate waste for roast lamb was more than twice as great as for roast beef and roast pork, when each was the only meat available. When a choice between roast leg of lamb and other meats was offered, roast beef and roast pork were chosen by approximately three times as many students and baked ham by five to nine times as many as was lamb.

Research on consumer acceptance and evaluation of lamb is nearing completion in Wyoming. Fifty percent of the households in one metropolitan area reported purchasing lamb at least once in the past year; 35 percent served lamb as frequently as once a month. Lamb was available in all of the large supermarkets in the area but was rarely carried in small retail stores. In the preference phase of the study consumers indicated that lamb cuts from a fat, heavy carcass were least liked. In general consumer preferences conformed closely to present retailer buying specifications--that is, a light carcass with a degree of finish bringing it to near choice grade. Socio-economic characteristics of lamb users in the area were reported.

The Georgia station studying the effectiveness of four media (TV, Radio, Newspaper, and Newsletter) in food education and promotion programs selected lamb as the commodity for test purposes. It was concluded that in the Southern city where the experiment was carried out there was insufficient use of lamb to effectively judge merits of several media studied. Deep seated attitudes regarding lamb were reflected in consumer response in that respondents reported they did not watch, listen, or read when they realized lamb was being discussed. Researchers indicated that over-time education and promotion programs might be more effective. Prior to initiation of program, 76 percent of the households reported never serving lamb and 8 percent reported serving lamb once a month. Fifty-seven percent of the families disliked lamb and 20 percent were not familiar with it.

Lamb Flavor

In a series of studies in the Washington Agricultural Experiment Station Marion Jacobson, Margaret Weller, Helen Koehler, M. W. Galgan and E. H. Rupnow are investigating the flavor components of fresh and cooked lamb and mutton. The effects of methods of cookery, spices, breeding and management on the possible alterations of flavor have also been explored. Chemical studies of the volatile and soluble non-volatile components of lamb have led to identification of some of the compounds contributing to lamb flavor. This work is continuing and has not been published.

Extensive and repeated taste panel tests with descriptive terms indicate that lamb and mutton flavors varied in fragrance, oiliness, sweetness, and a mustiness which is slight but distinctive. Lamb aroma was found to be highly volatile and easily altered by heat; also flavor components and precursors of flavor carried by the fat were readily soluble in cold water. Cooked lamb aroma was shown to have a moderate and balanced content of four characteristics classified as fragrant, acid, burnt, and capryllic. By comparison with chemicals, lamb aroma resembles in part the fatty odor of ethyl oleate.

Comparison of wether and ewe lambs (yearlings) with old mutton (8 and 10 year ewes) in two extensive series showed that advanced age was twice as important as sex of the animal in determining the flavor of lamb. Individual differences among animals was greater than differences owing to sex or age. Feeding of fish meals as 40 percent of the ration for 28 days to sheep did not affect taste scores for lamb. However, when the period of feeding was extended to 90 days, those animals on fish ration yielded meat which had an unacceptable "off" flavor.

Methods of cookery and seasoning were shown to affect lamb flavor. The extended time of heating with conventional roasting resulted in better flavor and lower cooking losses than electronic cookery. A limited study of herbs and spices added with salt to ground lamb is in progress. Thirteen of 38 seasonings added individually were judged as complementary to lamb flavor. Recommendations for use will follow final tests.

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K. WOOL

PROBLEM

Technology is imparting new properties to many of the wool fabrics on today's consumer market. The use of special-purpose finishes and constructions and the development of blends on mixtures with other fibers has broadened the use of wool, and has opened up possibilities for easier household care and maintenance. It has, at the same time, made inapplicable some of the traditional bases of fabric selection for various end uses. Research is needed as a basis for guides that will help consumers to select modern wool fabrics which provide the characteristics needed for satisfactory performance in specific end uses, and to select and use the methods best suited to making and caring for articles of clothing and housefurnishings of these fabrics. The importance of consumer-oriented research related to wool is indicated by the fact that some 37 percent of family expenditures for apparel and textile housefurnishings represent wool, according to weights assigned to cotton, wool and manmade fibers in the Consumer's Price Index of the U. S. Department of Labor.

PROGRAM OF THE STATE EXPERIMENT STATIONS

In this area, basic research at the New Mexico station was designed to provide evidence concerning the importance of selected fiber properties in imparting desired consumer qualities to wool fabrics. Other research of practical nature is providing facts on the performance of wool blankets (Minnesota and South Dakota) and wool carpeting (Kansas, Minnesota and South Dakota) that will serve as a guide to consumers in the purchase and care of these household textiles, especially as compared to those of other fiber composition. 1.3 professional man-years are devoted to research in this area.

RELATED PROGRAMS OF THE USDA

The USDA scientific effort devoted to research in this area totals 1.0 professional man-years.

PROGRESS OF STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

In the New Mexico research four lots of wool fiber selected for crimp and fineness were evaluated for the performance qualities they impart to garments made from the experimentally loomed fabrics. The garments, subjected to actual wear and dry cleaning, were appraised subjectively at successive wear periods and changes in the fabrics with wear were evaluated by physical tests. The research is not quite completed, but a few of the results published to date indicate that the fabrics from the fine wool tended to behave similarly and were higher in both strength and elongation than fabric from the medium wool.

The Minnesota and South Dakota stations have conducted interlaboratory studies of the characteristics of new and laundered blankets made entirely or partly of wool and man-made fibers. Qualities considered were those essential to comfort and warmth, namely, weight, thickness, thermal conductivity, air permeability and elongation. In the tests, the all-wool blankets were found superior to the wool blends. The all-wool ranked highest of all fiber types in warmth qualities, retaining this advantage even after 10 washings by proper methods, since thickness was retained. Tests are now being conducted on wool blankets treated for washability to determine the efficacy of this treatment in preventing shrinkage with laundering.

Interlaboratory studies to evaluate the service qualities of selected carpets are also underway at the Minnesota and South Dakota stations. Thirty-five carpetings, representing market offerings in different price ranges, have been characterized for fiber content and construction details, including weave, rows of pile per inch, pitch, stuffer yarns, yarn twist and ply. Of these carpetings, several types in the medium price range have been placed in service in heavy traffic areas, with maintenance by different household procedures. All wool carpeting of uncut and looped pile construction, and of twist construction, are included in the wear tests in comparison with similar carpetings in man-made fibers. Performance is being appraised by visual observation and laboratory tests. The Kansas investigation of 24 tufted carpetings, of different fiber content and construction detail, is being conducted on a laboratory basis involving simulated wear and artificial soiling, with soil removal by a standard technique. All-wool carpetings in the low and medium price ranges are included in the study.

Collectively, these three investigations will provide information on the relation of fiber content and carpet construction to desired service qualities such as ease of spotting and cleaning, color fastness, flammability, and resistance to crushing, abrasion and shrinkage. The facts will provide a sound basis for guidance to consumers in the purchase and care of carpets.

PUBLICATIONS REPORTING RESULTS OF STATE EXPERIMENT STATIONS AND COOPERATIVE RESEARCH

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